SCIENTIFIC INVESTIGATIONS OF ATMOSPHERIC PROCESSES

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QUARTERLY PROGRESS REPORT

SCIENTIFIC INVESTIGATIONS OF ATMOSPHERIC PROCESSES

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Visiting Scientists and Research Associates

Dr. William L. Crosson and Dr. Ravikumar Raghavan continue working as Research Associates on this project and the following is a description of their work. Dr. Charles Laymon collaborated with Dr. Crosson on work related to the Geographic Information System.

1. Activities Performed

Dr. William Crosson's activities on this contract have been directed toward modeling surface energy and hydrologic processes utilizing data collected during the Convection and Precipitation/Electrification Experiment (CaPE) held in east central Florida in July and August 1991. The objectives in this project are to establish and apply methodologies for the diagnosis of land and atmospheric water budget components for the CaPE region (approximately 25000 km2). The underlying philosophy guiding this study is that these techniques can be applied on scales consistent with GCIP activities such as the CART ARM experiment in Oklahoma and ultimately the Mississippi basin. Specific activities carried out to meet these objectives are as follows: Collecting and quality controlling data from the field program as well as from many other agencies, and using these data to diagnose surface energy and water fluxes for the CaPE region which includes raingage measurements, satellite imagery (SPOT, AVHRR, GOES), soundings, surface energy flux measurements, radar data and geographical information. The surface flux and meteorological observations taken by MSFC (3 sites), Florida State University (2) and the University of Georgia (2) have been quality controlled by the respective institutions and made available to the public through MSFC. The precipitation data set, consisting of data from a multi-agency network of more than 200 gauges, has required extensive assimilation and quality control effort, but has become a valuable research tool. Investigators from several other institutions have requested the data set for their own studies.

Dr. Crosson continues to build the Geographic Information System (GIS) database necessary for analysis of remotely-sensed data and for surface hydrologic and energy flux modeling. Soil types, topographic, hydrographic, basin boundary, and land cover data have been obtained and integrated on two GIS systems - the Image Station currently on loan from Intergraph, and the PC-based AGIS package. This work has been done in collaboration with Dr. Charles Laymon.

Daily rainfall analyses from the WSI radar composites have been completed for an initial set of 14 daily periods. These have been used as the basis for comparisons of daily rainfall estimated by the raingage network versus rainfall derived from radar reflectivities using published Z-R relationships. These comparisons indicate that the WSI radar composites overestimate rainfall over the CaPE region by an average of 70% for the 14-day period. Drs. Crosson, Claude Duchon and Ravikumar Raghavan have applied an alternative technique for estimating rainfall from the

radar data. This approach is based on matching the probability distribution functions (pdf's) of radar reflectivities and rain rates. The statistical analysis is based on 5 of the daily periods and applied to the other days as an independent test. The result of this work is a new 'climatologically tuned' Z-R relationship that is appropriate for the WSI composite radar product within the Florida summer climate. The application of this Z-R relationship results in rainfall estimates which are relatively unbiased with respect to gage amounts over large space and long time scales, although large discrepancies still exist at the local scale. Preliminary comparisons were made between rain volumes (from gridded radar and analyzed raingage measurements) integrated over various stream basins and stream discharge as measured by streamgauges. The purpose of this analysis is to gain an understanding of the response times involved for basins of different sizes. Ultimately the stream discharge measurements will be used to validate model-diagnosed runoff.

Dr. Crosson's work consisted of obtaining three scenes for the CaPE experiment. He derived surface reflectivities for each spectral band and calculated the Normalized Difference Vegetation Index (NDVI). Of interest for modeling activities is the spatial distribution of NDVI, and by inference vegetation properties such as leaf area index. He has examined the distribution of NDVI for each land cover type and observed large differences in the mean and variance properties. This information will be used to define sub- grid scale variability of vegetation conditions for modeling purposes.

A modified version of the Biosphere-Atmosphere Transfer Scheme (BATS) was tested using surface meteorological and energy flux measurements. The model has been applied using data from two of the CaPE surface flux sites; estimated heat and moisture fluxes are in good agreement with measured values. Model simulations have been performed for a composite data set derived from the 38 Portable Automated Mesonet (PAM) sites within our study area, with the aim of producing an initial estimate of areal heat and moisture fluxes. Thirteen of the PAM stations measured incident shortwave radiation; four of these also collected reflected shortwave, emitted longwave and net radiation, and soil temperatures, variables need as model input. Model sensitivity to radiation input will be tested using a variety of methods for specifying solar and longwave fluxes using the point measurements. For example, what is the impact on model-diagnosed fluxes of spatially uniform radiative input, as compared with values measured at each site? A more sophisticated modeling scheme for estimating areal fluxes for the CaPE domain has been designed. This method incorporates BATS, geographic information (landcover classes and soil properties), and statistical distributions of surface properties (such as leaf area index, albedo and fractional vegetation cover) based on high-resolution remotely sensed data. Distributions of NDVI and spectral albedo have been derived from 20 m resolution SPOT imagery for each of the 18 land cover classes in the study area. The BATS model will be run at grid points for the CaPE domain; each grid cell will be treated as a mixture of landcover types. To add further realism to the model, the statistical distributions of surface properties within each landcover 'patch' will be represented via a discrete probability density function inferred from the observed distributions of NDVI and albedo. Scale issues will be addressed with a series of model runs in which the resolution of remotely sensed data, used to establish the nature of surface variability, is degraded. Preliminary analyses have shown that degradation of SPOT data from 20 m up to 1 km resolution (simulating AVHRR footprints) results in large changes in both mean and variance of surface properties.

Dr. Crosson completed two, 3-day courses taught by Intergraph entitled Modular GIS Environment System Nucleus and Image Station Imager. In addition to this training, he spent a considerable amount of time at MSFC gaining experience in GIS applications.

Ravikumar Raghavan continues to perform research in the following areas:

- WSI-WetNet Marshall DAAC Operations: Algorithm design and Implementation for processing the real-time U.S. National Composite Radar Data being received at the Distributed Active Archive Center (DAAC) via satellite link. The WSI radar data is received via satellite every 5 and 15 minutes and will be stored on the Marshall DAAC. The U.S. National radar composite image is then converted to a U.S. National Precipitation (Rainfall) image. This image will be stored in the DAAC and will be made available as a browse product. The rainfall image will also be made available for distribution to the science community. Furthermore, the precipitation image will be made available on the LAN for viewing under the NASA Weather facility. Rigourous testing of the algorithm is being conducted in a modular mode and final implementation is being incorporated. The DAAC is expected to be on-line from January 1, 1994. NASA co-scientist: Dr. S.J. Goodman.

- Thunderstorm Electrification studies: Ongoing analysis of multiparameter radar data from the CaPE field campaign to study the microphysical characteristics, kinematics and morphology of clouds as well as the various processes that lead to the electrification and the subsequent production of lightning. NASA co-scientists: Dr. R. Blakeslee, Dr. S.J. Goodman and Ms. R. Hood.

The following abstracts and manuscripts were submitted for publication during this reporting period:

Raghavan, R., J. Turk and J. Vivekanandan, "Investigation of the Vertical Profiles of Linear Depolarization Ratio and Reflectivity at S, X and K Band Wavelengths, "Abstract submitted to the 1994 International Geoscience and Remote Sensing Symposium (IGARSS' 94) to be held in Pasadena, California.

Raghavan, R. and V. Chandrasekar, "Self Consistent Assessment of the Area Time Integral (ATI) Technique for Rainfall Estimates Using Multiparameter Radar," Manuscript being revised on recommendation by reviewers, *Special IssueJournal of Appl. Meteorology*, 1994.

Crosson, W.L., C.E. Duchon, R. Raghavan and S.J. Goodman, "Estimation of Rainfall for Hydrologic Application using Raingauges, Doppler Radar and Composite WSR-57 Radar Observations," Manuscript in preparation for submission to the *Journal of Appl. Meteorology*, 1994.

2. Problems

There were no problems encountered during this quarter.

3. Activities To Be Performed

Dr. Crosson and Dr. Raghavan will continue their research objectives relevant to the Scope of Work on this project.

4. Travel

Dr. Charles Laymon attended the Second International Conference/Workshop on Integrated Geographic Information Systems and Environmental Modeling to present a seminar entitled, "Rainfall - Runoff Relationship of the CaPE Experiment Area and Other Issues of the Surface Hydrology." The conference was held September 26-30, 1993 in Breckenridge, Colorado. Invoices were received during this quarter causing a delay in reporting.

Dr. Crosson attended the CaPE Workshop in Denver, Colorado, to make a presentation and to meet with Drs. Greg Scharfen and Ken Knoules at the National Snow and Ice Data Center, October 23-29, 1993.

5. Consulting and Workshops

No consultants or workshops were scheduled under this project during this reporting period.

6. Subcontract

There were no subcontracting actions during this reporting period.

Physical completion of the Statement of Work is consistent with expenditures to date. USRA has requested a no-cost extension to continue performance through February 28, 1994, letter PPC-93-320, dated December 28, 1993.

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15. Supplementary Notes

16. Abstract This contract will involve research in atmospheric dynamical and thermodynamical processes and in other disciplines necessary to accomplish the following tasks: Develop procedures for combining generalized radiative transfer codes with dynamic atmospheric model codes, perform diagnostic analysis of atmospheric processes to gain a better understanding of the evolution and development of mesoscale circulation systems and their precipitation structures and to develop algorithms and software necessary to graphically display diagnostic sets on the MSFC McIDAS and EADS to facilitate scientific study and sensor capability evaluation.

Research activities during this reporting period are detailed in the attached technical reports.

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